Space Weather Technical Forecast

Issued on Tuesday 8 October 2024 at 01:30 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1-G2 Minor/Moderate Storms easing day 1. Chance of further X-class flares. S1-S2 Minor/Moderate Solar Radiation Storm likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with peak flare X2.1 from AR3842 at 07/1913 UTC. This occurred simultaneously with a long period flare from just over the southwest limb, that peaked X1.0 at 07/2059 UTC, likely associated with AR3844. These are the most active regions of a collection of sunspots on the southwest limb that are becoming harder to assess, but remain likely flare sources given the associated bright magnetic looping evident on SDO aia imagery. There are nine regions in total on the disc, with other regions of note including the large, mature but inactive AR3848 in the north-centre disc and AR3849 and AR3850 in the southeast, although these have also remained inactive despite a small delta-spot being evident on the former. A further new region, AR3852 is also rotating onto the disc from over the southeast limb.

The X2.0 and X1.0 flares produced two CMEs, the first directed south and west of Earth, with the second on missing due to its limb location. Analysis is still ongoing with the south and west directed CME, however a glancing blow is possible, most likely 10 Oct. No other Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: Multiple weak CME enhancements were possible in this period, perhaps including the glancing influence of the 04 Oct CME, however nothing definitive was identifiable. The onset of any fast wind from CH78 also potentially occurred. Solar wind speed remained slightly elevated, between 400-500km/s, with density varying between below average and above average values. Interplanetary Magnetic Field, Bt, was mainly Weak to Moderate, between 8nt and 14nT, but rose to peak Strong at 16nT at times. The north-south component, Bz, favoured a negative (southward) orientation with only brief spells of positive (northward), and also varied between Weak and Moderate levels, ranging from -14nT to +12nT. Phi angle was near neutral at first, but became negative (towards the Sun) 07/1115-1915 UTC, then rotated to be positive (away from the Sun) by the end of the period. These changes perhaps showed the glancing CME influence, followed by the onset of fast winds towards the end of the period, however this is low confidence. Geomagnetic activity was mainly at G1 Minor Storm, with a couple of G2-Moderate Storm intervals (07/1200-1500 and 07/1800-2100).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 was at background for much of the period, but start to rise in response to the X-flares

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from 07/2325 UTC. This is expected to continue day 1 (08 Oct). High energy electron flux (greater than 2MeV) observed by GOES16 was at background to Moderate (at diurnal peak). The associated 24-hour fluence was below the Active threshold with 1.93e6 observed at 08/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: High to Moderate activity is expected, with a chance of further X-class flares before AR3842 retreats further onto the far-side through day 3 (10 Oct). Activity then easing to be Low to Moderate but with a slight chance of X-class flares from the other regions currently on the disc.

Solar Wind / Geomagnetic Activity: There are no further Earth-directed CMEs currently modelled, however analysis is ongoing for the large and bright X2.1-flare CME which may have a glancing component, most likely passing on 10 Oct (day 3). Otherwise the ongoing CME influence, along with any fast wind enhancement on day 1 (08 Oct) is expected to gradually ease. G1-G2 Minor to Moderate storms are likely to continue at first day 1 (08 Oct), easing to Quiet to Active with a chance of further G1 Minor Storms, and then mainly Quiet to Unsettled day 2 onward. Any further CME glance, most likely on day 3 (10 Oct) will bring a chance of further G1-G2 Minor to Moderate Storms.

Energetic Particles / Solar Radiation: The observed proton flux at GOES-18 is currently rising in response to the X-class flares late on 07 Oct. This is expected to continue through 08 Oct, with a likelihood of reaching the S1-S2 Minor to Moderate storm level. This is alongside the potential for further flares, which may lead to a further enhancement, given the location of AR3842. There is a slight chance of reaching the S3 Strong Solar Radiation storm level. High energy electron flux is also expected to gradually rise through the period, albeit with the typical diurnal oscillation, with the associated 24 hour election fluence responding likewise. This will bring a chance of reaching the Active threshold (1e8 total pfu) by the end of day 3 (10 Oct)

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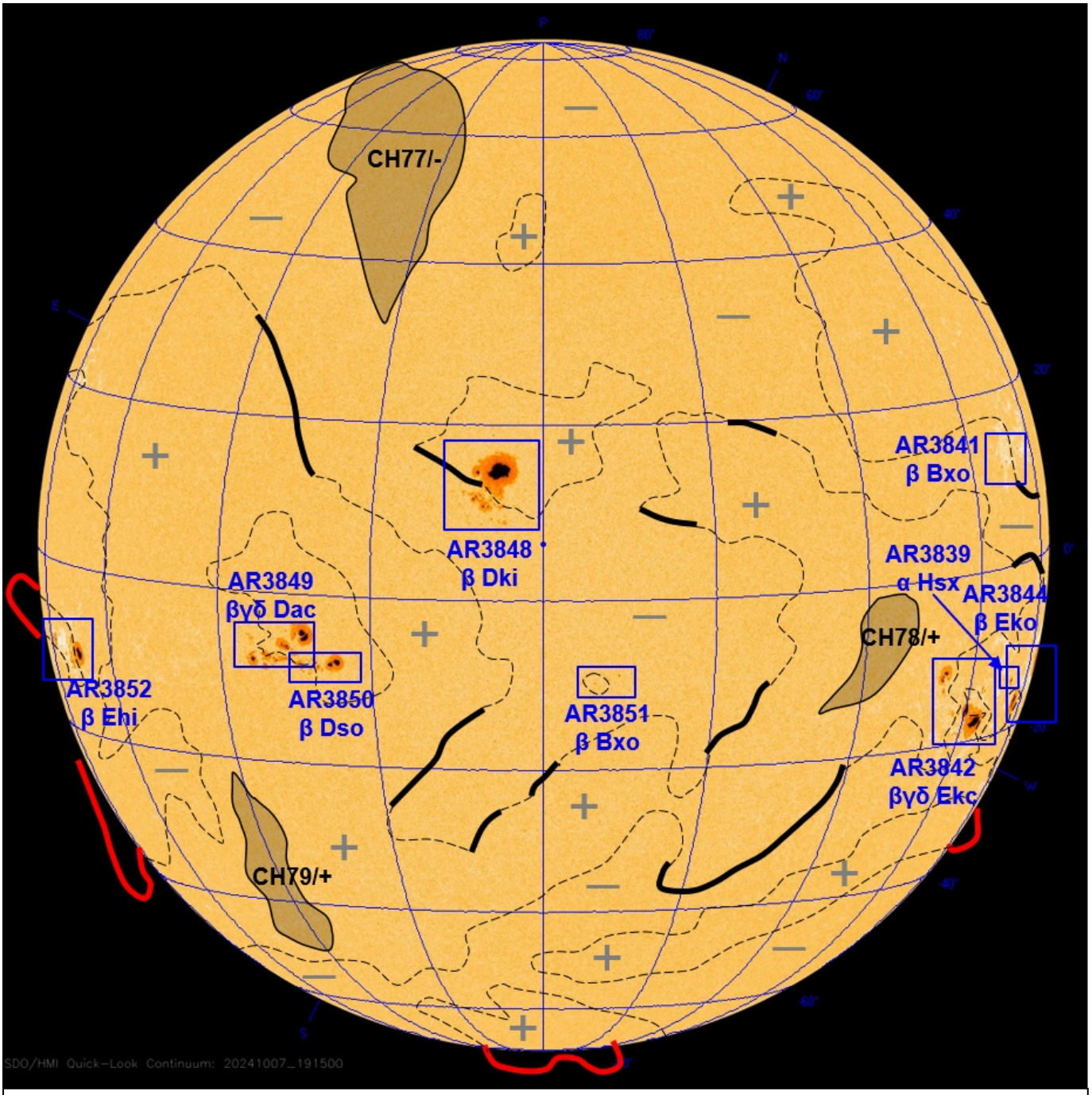
Figure 1: Solar Synoptic Map 07/2000 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

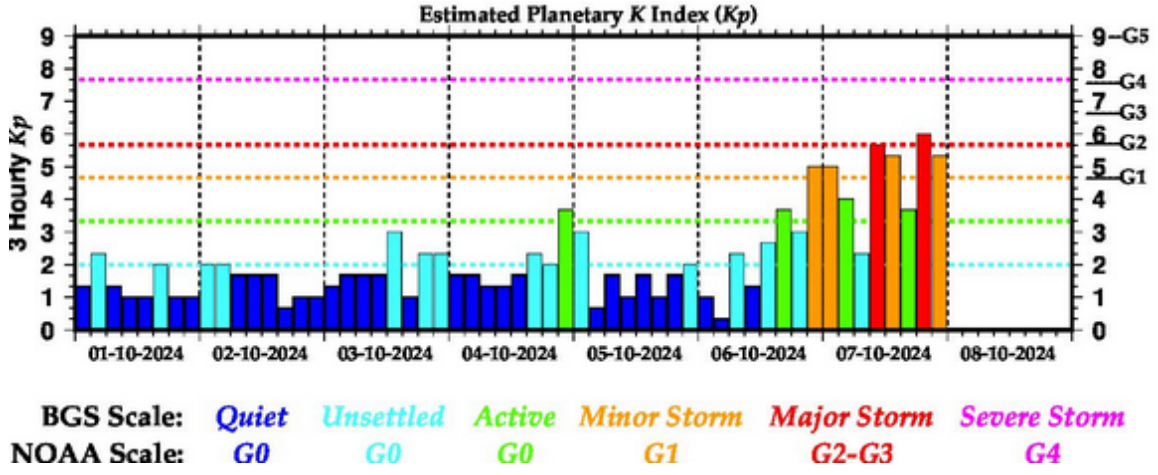
There are no further CMEs currently expected to arrive at Earth, however the large and bright CMEs evident from the X2.1 and X1.0 flares has yet to be fully assessed. The first of these may have a glancing impact, most likely early day 3 (10 Oct) with the latter likely on the limb and missing.

The solar wind environment around Earth remains disturbed at first, due to ongoing CME influences after potential arrivals on 06 Oct and 07 Oct. This has been further disturbed by a potential transition into the fast wind of CH78/+, with winds likely to rise to elevated or near elevated, 450-500km/s, during day 1 (08 Oct). This is low confidence however, with MOSWOC not featuring this enhancement. And fast wind enhancement is then expected to ease to background, but may be enhanced for a time day 3 from any CME glance.

G1-G2 Minor to Moderate storms, with a slight chance of an isolated G3 Strong storm interval at first. However this risk will quickly recede, with activity becoming Quiet to Active with a chance of G1 Minor Storms for much of the day, before easing to mainly Quiet to Unsettled by day 2 onward. However any glancing impact from the CME will bring a chance of further G1-G2 Minor to Moderate storms day 3, however this is currently low confidence.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	10	30	1
Strong	G3	No	20	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: BGS Geomagnetic Activity



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Radio Blackouts - X-Ray Flares

Moderate to High activity is expected, with a very slight chance of becoming Very High on days 1-2, before this risk fades day 3 onward.

The main source of this potential activity is AR3842, which was the source of recent X7 and X9 flares, and the X2 flare on 07 Oct. This is now hard to assess, approaching the southwestern limb, but features a strong and persist delta spot, and since the X2 flare has bright and notable looping evident within the corona above the region. This X2 flare also saw some contribution from AR3844 on the limb, with the combined effect resulting in of the very long period M-flare, which just peaked into X1.0 for a few minutes around 07/2100 UTC. This regions also contributes some of the flare risk on day 1 (08 Oct).

Along with these two regions, there are small contributions from AR3848 in the north-centre disc, AR3849/AR3850 in the southeast, and AR3852 now emerging onto the southeast limb. AR3848 has been a benign and stable region, with a mature but strong positive main spot, and small negative spots on its southern periphery. AR3849 and AR3850 form an entangled pair of region, with the former having a very small and weak delta spot, but overall a relatively simple bipolar configuration and aligned east-west. AR83852 also appears to be a magnetically simpler region on the east limb, but with a large leader spot, however this remains too close to the limb to fully assess.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 (M Class)**	Yes	80	80	70	60
Very Active	**R3-R5 (X Class)**	Yes	40	40	20	10

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Figure 3: GOES-16/18 X-ray flux.

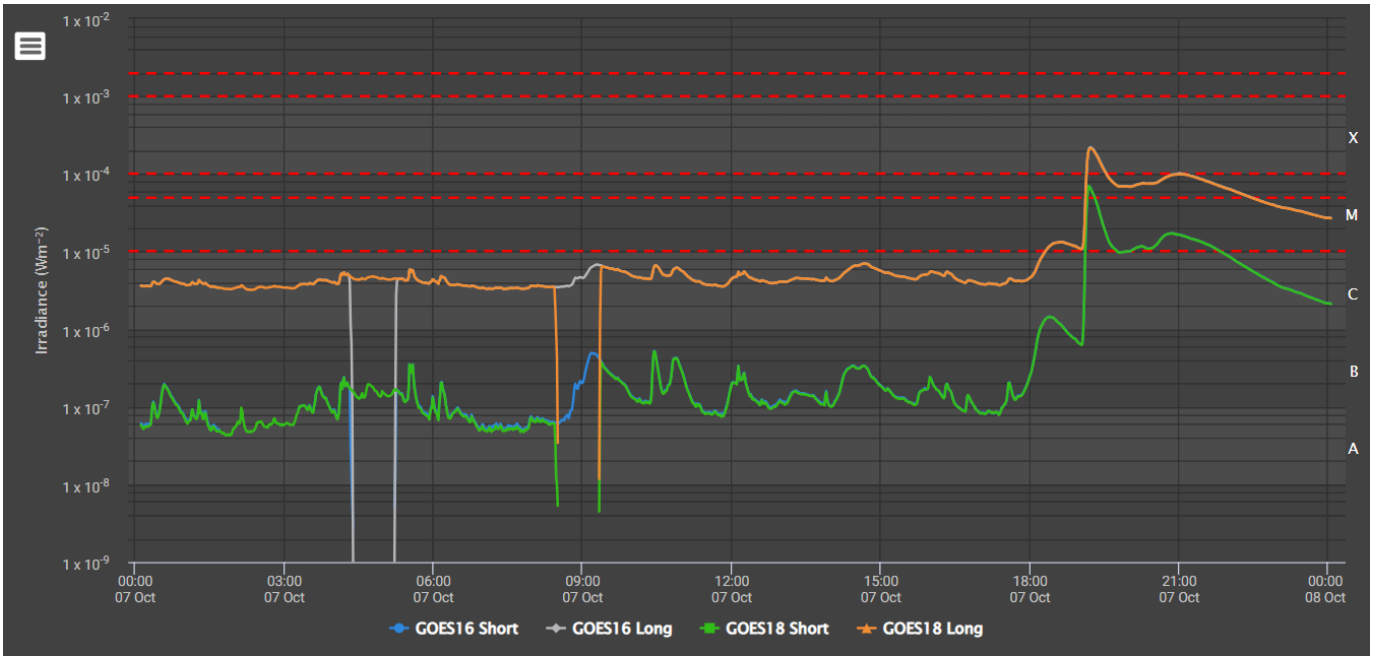
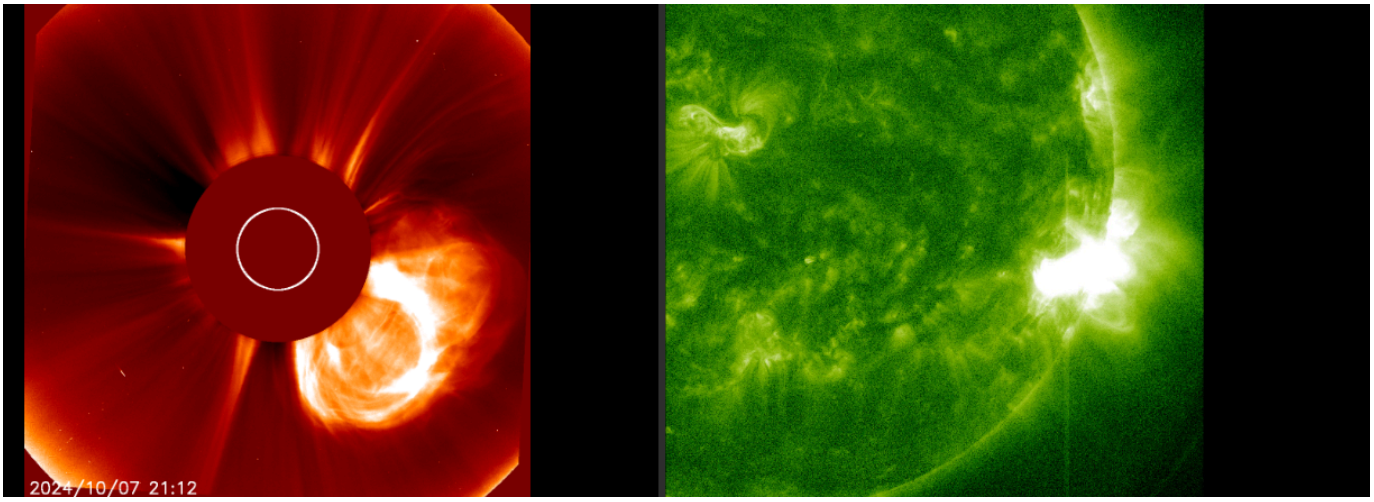


Figure 4: X2.1 flare and subsequent CME



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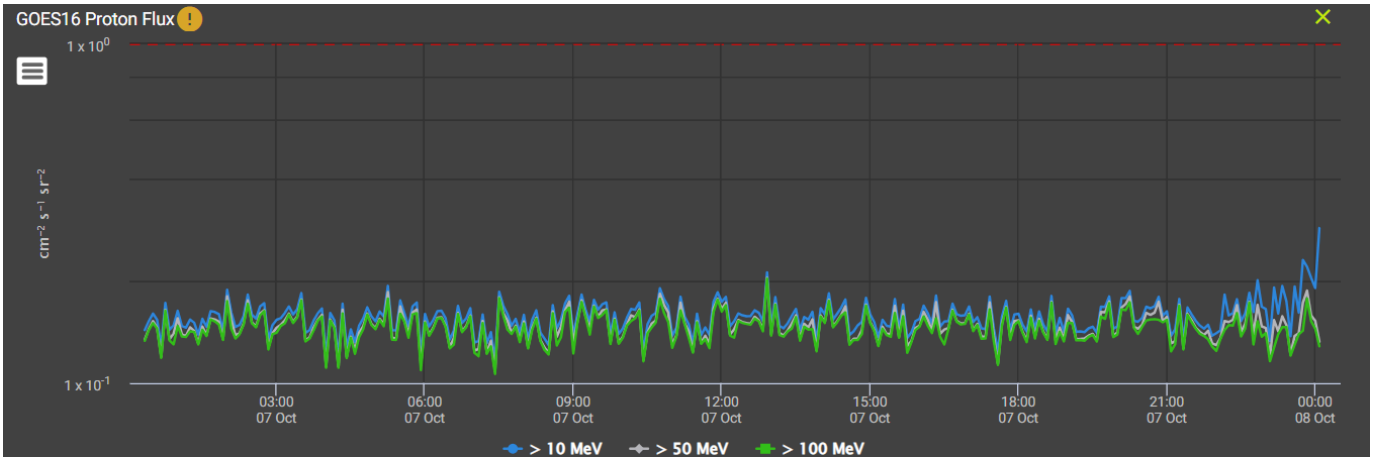
Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 are just started to respond to the X2.1 and X1.0 flares that occurred late on 07 Oct, and given the occurrence of Type II and IV radio bursts, a large CME, the southeastern disc location of the flares and the longevity of them, then a more notable response is likely early on day 1 (08 Oct). This brings the likelihood of proton flux reaching S1-S2 Minor to Moderate Solar Radiation Storm on days 1-2 (08-09 Oct), before this risk recedes. There is a slight chance of reaching the S3 Strong Radiation Storm level.

Further flares from these regions will also bring an increased chance of seeing proton flux rise at GEO, although this risk recedes later day 3 and day 4 (10-11 Oct) as AR3842 retreats onto the far-side, with the other regions on the disc currently relatively inactive.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	70	50	20	10
Very Active	**≥ S3 ***	No	10	5	5	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5:



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High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) observed by GOES16 was at background, likely suppressed due to ongoing solar wind enhancements from the recent CME arrival and the potential transition into any fast wind from CH78. These have likely increase electron populations at lower orbits however, and as solar wind pressure subsides and the Van Allen belts return outward, flux is expected to rise at GEO. This likely giving Moderate, perhaps diurnally High values by day 3 (10 Oct) onward.

The associated 24 hour fluence is expected to persist below the Active threshold, but with a rising trend later in the period, bringing a chance of reaching the Active (1e8 total pfu) level by the end of day 3 (10 Oct). This rising trend is supported by REFM, however this is likely underplaying the expected values by the end of the period.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}sr^{-1}day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ 1×10^{8}**	No	1	5	25	25
Very Active	**≥ 2 MeV ≥ 1×10^{9}**	No	1	1	1	1

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